Wall Building

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Case Study

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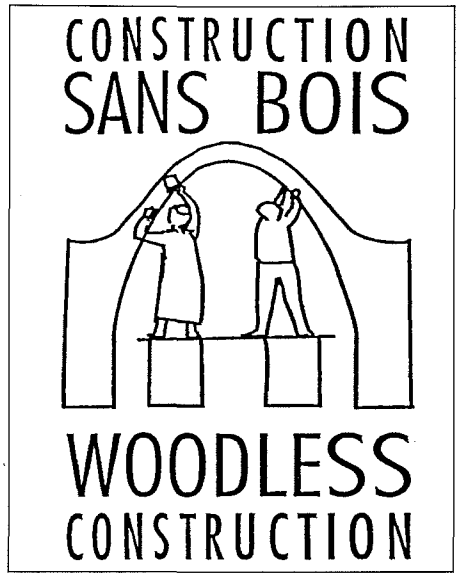


Woodless Construction – 3
Change and adaptation to local needs: A case study in Mopti, Mali

"Woodless Construction" is the name that has been given in the Sahel to the construction of buildings, in which all the structural elements, including the vault and dome roofs, are made of ordinary mud bricks.

Woodless Construction was developed to provide a viable, affordable and accessible alternative to a dual problem: how to alleviate pressure on the threatened natural resources of the Sahel and at the same time to make building by the population easier (see *Woodless Construction – 1: An overview* in this series of BASIN case studies).

The bricks for both walls and roofs are formed in rectangular moulds, smoothed by hand and left to dry in the sun for a few days – a method very widely known in the region. During construction, the dried bricks are laid in mud mortar. The vault and dome roofs are built using techniques which originated in Iran and Egypt. The most important characteristic of these roofs is that they are built without any supporting shuttering. Thus the entire structure – walls, lintels, and roofs – is built with locally available earth.

Figure 1 Ordinary mud bricks of local dimensions are used as the unit of measurement in laying

In order for the key process of training and dissemination to be effective, the way Woodless Construction techniques are both taught and used in the Sahel has, since the time of their introduction,[1] been the object of an ongoing process of evolution and adaptation to local conditions and training needs. (For more detail on the organisation and content of training cycles, see *Woodless Construction – 2: The training of trainers and builders: a case study in Filingué, Niger* in this series of BASIN case studies). This process of adaptation has naturally drawn upon Development Workshop's earlier experience of building with vaults and domes in Egypt, Iran and Tunisia – all countries which have differing techniques adapted to their own local context. For example, the well-known traditional domes and vaults of Egypt are in an extremely arid region; for them to be viable in the Sahel, which despite low *annual* rainfall is liable to violent rainstorms, much adaptation has been needed, primarily to ensure rainwater run-off. Adaptation has also, however, reflected *observation* of local building techniques in the Sahel and *discussion* with the builders of each locality. The evolution of building techniques and forms is thus inspired by local practice, by a vast range of building techniques and styles, and thus by local solutions to problems and needs. Finding a solution to today's needs is thus a question of mixing existing local ideas with new techniques, the latter being needed where old practice is no longer viable.

In practical terms, adaptation of the traditional vault and dome techniques has focused on two main aspects:

- making the techniques *easier to learn and use* – often for illiterate and sometimes non-numerate builders – and thus safer;
- making the techniques *respond to local needs and expectations* – which includes keeping costs low and providing the shapes and appearance that the public want.

A training cycle run by Development Workshop in 1993 in Mopti (Mali), where there is a rich and diverse tradition of earth building, highlights a number of examples of such adaptations.[2] These adaptations reflect both local conditions and building habits in the Mopti region and the high level of skill amongst local builders. They are therefore described below essentially to illustrate the nature of the *process* of adaptation and not as universally applicable recommendations.

1 Development Workshop introduced woodless vaults and domes to Niger in 1980 at the request of a small Canadian NGO, ISAID, in the context of a rural development programme.

2 This cycle took place in the context of the Woodless Construction training and awareness-raising programme, executed by Development Workshop

Figure 2 "Alcove" building under construction. Note the use of strings as a guide, the practice of starting the vault from both ends simultaneously, the use of off-centred vaults and open arches to create a spacious interior.

Making Woodless Construction easier to learn and use

A primary objective of any Woodless Construction training cycle is to teach local masons how to build earth walls, as well as earth vaults and domes safely. The experience of training and building in the region of Mopti, however, also confirmed the need to make "good" building practice compatible with pragmatic building methods – methods the builders will really continue to use after training. Buildings with vaults and domes are subjected to greater outward forces than those with flat roofs. It is therefore often the case in the Sahel that local wall building techniques which are adequate for flat roofs would be dangerous for vault and dome roofs.

Brick sizes and laying methods

Over the years emphasis has been placed on the quality of wall building. During the 1980's this meant focusing particularly on brick dimensions, bonding patterns and laying techniques, working to precise plans. It became apparent, however, that such relatively complex and precise practice was acting as a break on the assimilation of the techniques. To take one example, courses with headers and stretchers were used, but these required scaffolding inside and outside the building. Local scaffolding is although therefore made sense to build using header courses only. The wall-building taught in Woodless Construction activities, therefore, changed to headers only, but initially still using a special brick dimension ensuring good bonding. This practice gave excellent results and remains popular today. Introducing unfamiliar sized bricks, however, in turn acted as a break on acceptability. Starting to use local bricks whatever their dimensions (provided using the same size brick in any one building) was a logical step, whilst taking great care to ensure good bonding. It was important to eliminate the cutting of bricks to fit measured wall lengths (a trimmed block facilitates corner strength) and this was achieved by stating only approximate wall dimensions on plans and allowing builders to work to the nearest brick when laying out.

These progressive adaptations – "headers only" courses, using local size bricks and using the local size brick as a unit of measurement – took place over some 13 years.

Training structures

Historically, the vault and dome techniques used in Iran or in Egypt were passed from one generation to the next through apprenticeship. In the Sahel this slow process needed to be speeded up, to allow new woodless construction builders to learn than years. In the Mopti training cycle, the use of special training structures on which trainees could practice building arches, vaults and domes, without the constraints of a building site was introduced. These included walls to start off vaults, bases for domes, small structures to practice openings and even small complete rooms.

String guides for vault building

In addition, string guides had been used since early on in the introduction of vault building to the Sahel (1980) to help builders follow a straight line as they built out the courses of bricks from the end supporting wall. But drawing up the correct shape of the vault on the end wall, however, remained a problem.

Drawing the vault shape

Gradually a method has developed using wires or string and small pegs which together with a table of dimensions allows masons to trace correctly any vault in the range of spans he needs. The same piece of string is used again to control the correct angle of bricks as they are laid, by stretching the string across the face of the vault. These simple methods quickly become habit to the trained masons. Almost perfect vaults can be mastered in a matter of days.

Three profiles of vault had been regularly

66% and 75%, but over time such diversity was judged unnecessary. A vault with a height to span ratio of 66% was adopted as a "standard". But in Mopti, it soon became apparent that to offer a locally acceptable building solution it would be necessary to provide flat roofs using secondary vaults and infill. The 66% rise to span was therefore replaced by a new 60% form, easier to "convert" into a flat roof.

Off-centred vaults

For improved economy, strength and use of space, where two or more vaulted rooms were being built side by side, "off-centred" vaults were also introduced. This means that the external side of the vault can be started very low down, with a minimum of outward thrust, whilst the internal side of the vault can be finished much higher up. The resulting rooms have more vertical walls against which furniture can be placed, and opening between adjacent rooms is made easier. Off-centred vaults can only be built where two roof structures provide an opposing thrust.

Responding to local needs and expectations

Adapting the form or appearance of Woodless Construction buildings makes assimilation by the population easier. "Standard" forms and designs are deliberately avoided. Instead, builders are encouraged to see that, taken as a whole, even simple Woodless Construction techniques can quickly be used as a 'kit' which can be adapted to suit many needs.

Flat roofs on vaults and domes

Popular reaction to Woodless Construction in the Niger interior river delta region of Mali in 1991-92 had shown that Woodless Construction rapidly aroused strong local interest in the face of increasing difficulty in finding organic materials or the money to pay for non-local alternatives. People nevertheless wanted *flat* roofs, where they could sit and sleep during the hot season: flat roof terraces with vaults and domes, using secondary vaults in the "voids" between the main roof vault and then infilling with earth, were therefore introduced. Skilful use of off-centred domes and vaults reduces enormously the need for secondary vaults and infill in the roof, an otherwise expensive item.

Reduced wall thickness

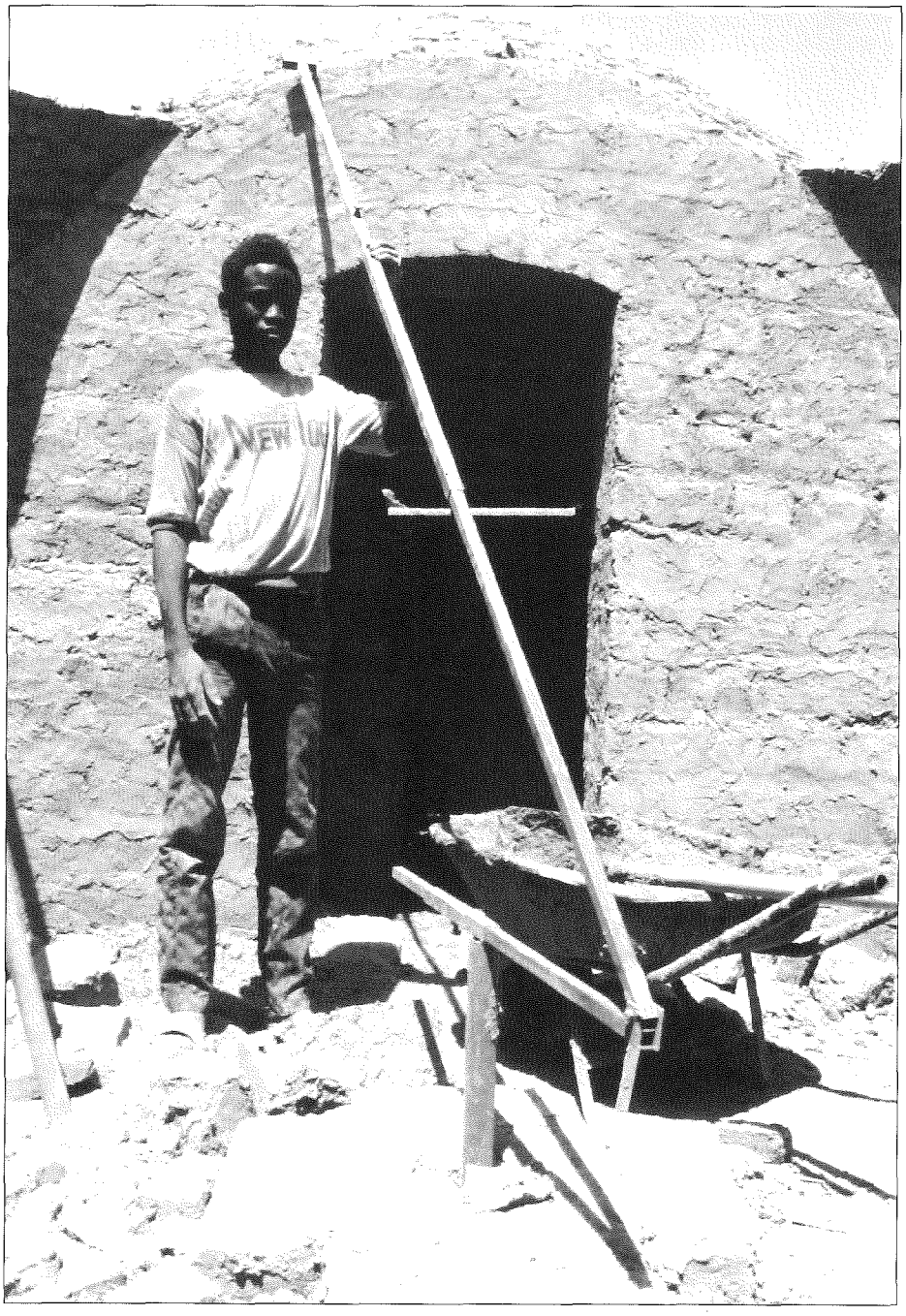
Woodless construction is mainly about changing the way that people build roofs, but the paradox is that walls invariably cern amongst clients and builders is how much material goes into the walls. In Mali, the programme worked to develop structures which reduce wall thickness and volume, and thus lower costs and building time.

Increasing convenient interior space

Following from this, "alcove" buildings were also demonstrated in Mopti. These exploit the fact that although vaults and domes require either thick walls (or a counter-force from an adjacent roof to contain their outward forces), these thick walls need not be solid. They can therefore contain alcoves which can be both attractive and functional (e.g. to hold a bed, cupboard or toilet) and moreover represent a considerable saving in bricks. Thick walls containing alcoves can be economically built so that they can resist the thrust of much flatter vaults or domes. The advantages here include using less bricks, faster building and a shallow roof, built using just the upper half of the vault profile: the resulting shallow curved vaults lend themselves more easily to infilling for flat roofs.

"Gothic" domes

Creating flat roofs is one issue; making sure that roof forces pass as vertically as possible to the ground is also important – doing so can reduce wall thickness and the number of bricks in the wall. Rather than building hemispherical domes in the traditional Nubian style, "Gothic" (i.e. eccentric) domes have been used. The metal rotating arm which is used for positioning each brick in the dome is set up so that the base of the guiding arm is displaced from



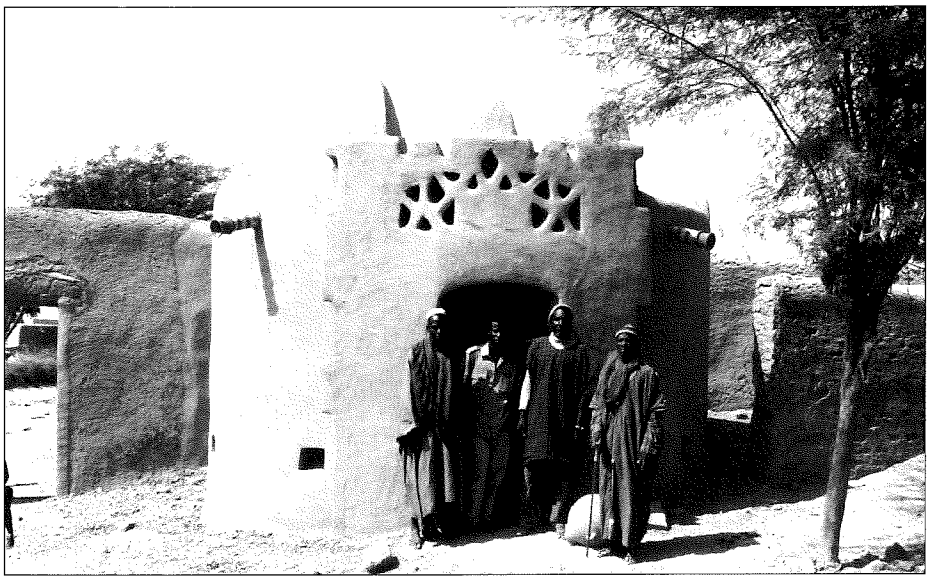


Figure 4 Woodless Construction clients often attach great importance to the final appearance of their building. This round, domed building is finished in the manner locally typical of rectangular, flat-roofed buildings.

the centre of the room (usually by one third of the dome's radius). This gives a steeper curve to the profile of the dome, reduces outward thrust, and enables the dome to be started lower down whilst still achieving the same room height. Not only is the result stronger and requires less wall structure, but the annoying echo of hemispherical domes is also reduced. (An adjustable metal guide is given to each mason to keep when he completes his training).

Retro-fitting vault and domes

In the Mopti region, existing earth buildings with thick mud masonry walls also abound. The idea of "retro-fitting" existing (former wood structure roof) buildings with new woodless roofs was successfully tried, always provided of course that the walls were strong enough and the roof concept suitable. In the Mopti region, several buildings were retro-fitted with vaults and/or domes: an office, private houses, and one mosque, the latter proving to be a great source of pride to the local villagers who enthusiastically contributed their labour.

Future directions

Technical changes are making Woodless Construction building easier and more attractive to clients. But just as important is the impact that these changes are having on how local masons and clients are taking decisions into their own hands: laying out bricks to measure the size of a new building on the ground, and then "re-arranging" rooms to suit the client's wishes; or trying out different vault positions by drawing full size on the wall. All increasing opportunities for masons to find viable solutions to local clients' needs unaided.

For more information on Woodless Construction, contact:

John Norton,
DEVELOPMENT WORKSHOP,
B.P. 13, F – 82110 Lauzerte, France
tel: (+ 33) 63 95 82 34
fax: (+ 33) 63 95 82 42,
E-mail: dw @globenet.gn.apc.org

Published by

German Appropriate Technology Exchange
Dag-Hammarskjöld-Weg 1
Postfach 51 80
D - 65726 Eschborn
Federal Republic of Germany
Phone + 49 - 6196 - 79-3190
Fax + 49 - 6196 - 79-7352

What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers four principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

All four groups have a co-ordinated database from which information is available on Documents, Technologies, Equipment, Institutions, Consultants as well as on Projects and Programmes. In addition, printed material or individual advice on certain special subjects is provided on request. Research projects, training programmes and other field work can be implemented in co-operation with local organizations, if a distinct need can be identified and the circumstances permit.

BASIN is a service available to all institutions and individuals concerned with housing, building and planning in developing countries, but can only function efficiently if there is a regular feedback. Therefore, any publications, information, personal experiences, etc. that can be made available to BASIN are always welcome and will help BASIN to help others.

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WAS / BASIN
GATE - GTZ
P.O.Box 5180
D - 65 726 Eschborn
Germany
Phone + 49 6196 793190
Fax + 49 6196 797352

Cements and Binders

ITDG
Myson House
Railway Terrace
Rugby CV21 3HT
United Kingdom
Phone + 44 1788 560631
Fax + 44 1788 540270

Roofing

SKAT
Vadianstrasse 42
CH - 9000 St. Gallen
Switzerland

Phone + 41 71 237475
Fax + 41 71 237545

Earth Building

CRATerre – EAG
Maison Levrat, Rue du Lac
BP 53
F - 38092 Villefontaine Cedex
France